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TITLE

OBJECT CREATION AND HUMAN FACTORS EVALUATION  
FOR VIRTUAL ENVIRONMENTS

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NASA/MSFC:

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## Introduction

The main objective of this project is to provide test objects for simulated environments utilized by the recently established Army/NASA Virtual Innovations Lab (ANVIL) at Marshall Space Flight Center, Huntsville, Al. The objective of the ANVIL lab is to provide virtual reality (VR) models and environments and to provide visualization and manipulation methods for the purpose of training and testing.

Visualization equipment used in the ANVIL lab includes head-mounted and boom-mounted immersive virtual reality display devices. Objects in the environment are manipulated using data glove, hand controller, or mouse. These simulated objects are solid or surfaced three dimensional models. They may be viewed or manipulated from any location within the environment and may be viewed on-screen or via immersive VR. The objects are created using various CAD modeling packages and are converted into the virtual environment using dVise (Division, Inc., 1997). This enables the object or environment to be viewed from any angle or distance for training or testing purposes.

In order to provide environments with the objects used in testing and training, models were created that focused on the primary project or task. Building on comparison and human factors projects completed during a previous NASA Summer Faculty Fellowship in 1993-1994, objects individualized for the X-34 virtual model and X-34 virtual maintenance environment were created using AutoCAD Release 13 (AutoDesk, 1995) and 3-D Studio (AutoDesk, 1994). These models included dVise's Manikin human figure models) of 5th, 50th, and 95th percentile American males, graphic representation of reach envelopes for each of these Manikins, and a manipulatable flexible air hose for the X-34 environment. The X-34 model and environment were created by Orbital Sciences Corporation and Marshal Space Flight Center.

The current primary task of the ANVIL laboratory is to use VR technology to enhance, animate, test, and document a design of the engine cavity, engine access hatch area, and maintenance environment for the X-34 sub-orbital vehicle. However, the general purpose nature of VR technology makes it an intelligence enhancing tool for a wide range of disciplines (Rheingold, 1991b) and the creation of manipulative input devices have simplified the interaction process between user and computer. These innovative input devices use hand or body movements instead of using complicated computer commands. The ease of interaction, and the use of wearable display equipment make it possible for the participant to view and to move through a simulated environment (Chung, 1989). VR's primary effect is to place a person into a simulated environment that looks and feels to some degree like the real world" (Psotka, 1994, p.1). however, reveals the motion of the hose as it is moved by the user.

The flexible hose will be incorporated into the latest version of the X-34 virtual maintenance environment where human factors testing will occur pertaining to its Using VR simulation of objects and environments, interactive computer programs have utilized the computer's advantage in memory and calculation

along with the human advantage in evaluation and putting ideas into context (Brooks, 1988). These advantages are magnified with the use of VR enhancement tools. These tools permit the user to utilize natural movement rather than typed instruction or symbols and words picked from a menu (Rheingold, 1991b). Among VR's advantages are opportunities for viewing and evaluating a selected object or environment that is difficult or expensive to access due to a remote or inaccessible location or one that is planned but does not yet exist. The importance of these factors (interaction, simulation, and natural movement) lies largely in their potential for achieving economic efficiency in understanding the nature of human-environment interaction (Craig & Feimer, 1987).

### Volume Visualization

Three-dimensional objects are necessary for volume visualization, a concept that is difficult for most individuals. While we see in three dimensions, we are accustomed to looking at consolidated information on two dimensional media, whether it be graphic or text. A method of extracting information from a three-dimensional environment is necessary and is available in virtual reality environments which are essentially volumetric data sets. Information may be extracted from volumetric data sets through interactive graphics and imaging (Kaufman, 1996, p.1). Meaningful information that aids the understanding of volume may be extracted from computer graphics by using transformations, segmentations, translucency, and measurements (Kaufman, 1996). Two of these methods--translucency and measurement--will be utilized by the Manikin models and reach envelopes to extract information about X-34 engine extraction and maintenance. Measurement can be used when incorporating the flexible hose into a test or training session, or example on engine extraction.

### Process

The process of creating three dimensional models and incorporating them into virtual environments is a time consuming and labor intensive one. It is important, however, that objects be in the scale of the parent environment and be as much like the real object being replicated as is possible (Lindsey, 1995). Inaccurate scale or representation can skew test results or provide ineffective training. Each segment of each model must be carefully dimensioned and then reproduced accurately along the x, y, and z axes so that it may be placed properly into the environment.

### Creating and Testing Manikins and Reach Envelopes

The dVise standard male Manikin was used as a starting point to develop sample test human figures across the range of body sizes required for NASA development of NASA engineering designs. Using NASA standards NASA (1989) were used to modify the dVise Manikin represent a fifth, fiftieth, and ninety-fifth percentile American male as closely as possible. Each of the three Manikins was placed within the

test environment at a specified point at the X-34 engine maintenance hatch and using the dVise inverse kinematics, the reach capabilities of each of the three Manikins were compared by specifying individual engine parts could be reached.

A graphic representation of a reach envelope was used for comparison or reach inclusive areas, rather than specific objects (Figure 1). During this process, it was discovered that the dVise reach envelope exceeded the reach of the Manikin human figure, causing skewing of the information being gathered. New graphic representations of reach envelopes for each Manikin was developed using AutoCAD (AutoDesk, 1993). The newly designed envelopes were anthropometrically correct for each of the Manikins used for testing.

Again, each Manikin was placed at the engine cavity hatch of the X-34 virtual model and tested with the graphic reach envelope engaged and intruding into the engine cavity. By observing the reach envelope shell, information was gathered on which of the engine components might be reached by Manikins of the specified body sizes. The components that could be reached were determined by their inclusion in the reach envelope shell.

### Flexible Air Hose

Compressed air powered wrenches will be used for maintenance of the X-34. The hoses are space consuming and kinetic. The motion of the hose is created by the user, but is passed on down the length of the hose due to its somewhat rigid nature and its rotation on the two axes only. This motion characteristic presents potential problems for technicians working at the engine cavity aperture. In order to test for problems that may occur in handling this motion and space intensive piece of equipment, a test model was created.

The original object, one three inch long segment, was created in AutoCAD. Copied multiple times, the segments were aligned end-to-end until a usable length of hose was created. This CAD drawing was then imported into 3D Studio where links between each segment and a hierarchical structure were established. The flexibility of the hose was restricted to 30 degrees. The rotation along the length of the hose was then set to zero so that the hose would rotate only around the y and the z axes, emulating accurate motion. The hose was presented via two types of animation: automatic and interactive. The automatic animation simply demonstrates the range of motion of the hose as it moves along a pre-determined path. The interactive hose, however, reveals the motion of the hose as it is moved by the user.

The flexible hose will be incorporated into the latest version of the X-34 virtual maintenance environment where human factors testing will occur pertaining to its

function and spatial needs. It will be controlled by a data glove so that the user may move the hose at will in the X-34 environment and observe how the hose reacts the user-generated motion. The hose, maintaining its kinematic capabilities, may be scaled up or down and have its rotation restrictions modified to represent similar pieces of equipment

such as cables and hoses of alternate size and flexibility.

#### Conclusions and Expectations for the Future

This decade has been a succession of study, research, writing and activity in the evaluation and use of virtual reality technology for predicting the success of behavioral environments. Object creation for the use of human factors evaluation is the least time effective part of setting up an environment to be observed via VR technology. While there are commercial templates on the market, many times templates must still be customized. The object creator must understand scale and function of the subject environment and must stay in constant contact with the person who will convert the CAD objects into components of the VR environment. Specific elements must be included or deleted from A CAD drawing in order to convert it. Additionally, it is helpful for the object creator to be able

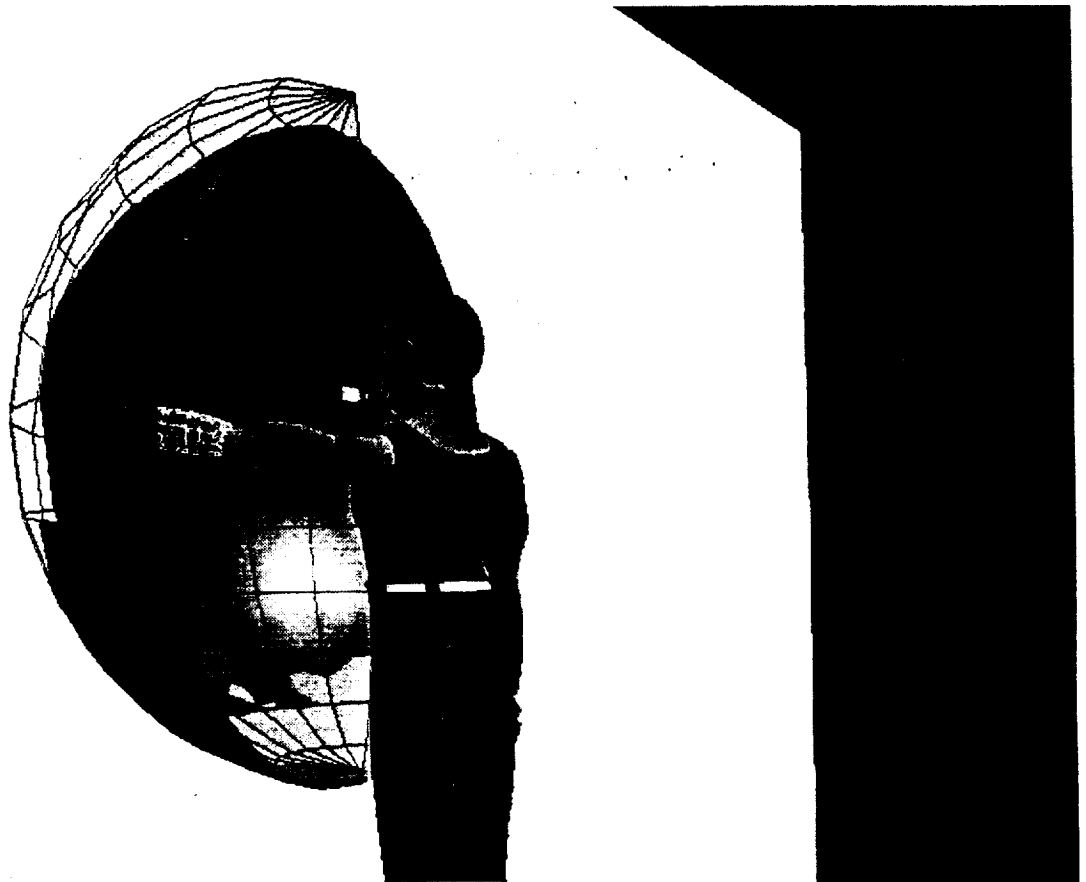


Figure 1.

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to run the animation system in order to test our the success of the object within the environment, so that needed adjustments may be made.

It appears that ease of use of primitive shapes will increase in CAD packages in the future to reduce the time expended creating three dimensional objects. Since VR software necessitates the conversion of objects from CAD and modeling packages, a more sophisticated and interactive conversion method should be developed. Too many times, part of an object or its surface texture is lost during the translation from CAD to VR. As with all uses of electronic graphics, more uses will be found for the technology and the temporal problems will become less accute.

### Collaborations

Efforts in to create and include necessary objects into the X-34 virtual environment and to establish them in an interactive mode could not have taken place with out the efforts of Leigh Lunsford, Ph.D., and Joe Dumas, Ph.D., Summer Faculty Fellows in the ANVIL lab. Dr. Lunsford manipulated and animated the X-34 environments via software customization Dr. Dumas wrote devise drivers that incorporated the interactive VR equipment making the environments immersive and responsive to user manipulation.

We all worked under the guidance and with the help and advise of NASA mentor, Joe Hale and permanent ANVIL engineers, Mark Blassingame and Chris Daniel.

### References

- AutoDesk, Inc. (1990). 3D Studio. Autodesk, Inc. Publication, Sausalito, CA.
- AutoDesk, Inc. (1993). AutoCAD. Autodesk, Inc. Publication, Sausalito, CA
- Brooks, F. P., Jr. (1988). Grasping reality through illusion. In E. Soloway, D. Frege, & S. Sheppard (Ed.), CHI Proceedings, 1-11. Reading, MA.
- Chung, J. C. et al. (1989). Exploring virtual worlds with head mounted display. Non-holographic, true 3-dimensional, display technologies. SPIE Proceedings, Vol. 1083, Los Angeles.
- Division Inc. (1997). dVISE 4.0.0.
- Kaufmann, A. E. (1996). Volume visualization. ACM Computing Surveys, 28, 1, 1-3.
- NASA (1989). Man-system integration standards. NASA-STD-3000. Volume I, Revision A. National Aeronautics and Space Administration. Scientific and Technical Information Office.
- Lindsey, P.F. (1996). A comparison of spatial interpretations of NASA's payload operations control center, marshall space flight center, using real world and virtual reality observations. Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA.
- Psotka, J. (1994). Immersive tutoring systems: Virtual reality education and training. Available: <http://alex-immersion.army.mil/its.html>.

